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(54) **TIRE TEMPERATURE PREDICTIVE SYSTEM AND METHOD**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,805,864 A	*	4/1974	Tsuruta	B60C 23/18 152/153
3,934,452 A	*	1/1976	Prevorsek	G01M 17/02 374/47
4,130,154 A	*	12/1978	Hampshire	B60C 17/04 152/158
4,362,200 A	*	12/1982	Standley	B60C 9/1821 152/153

(Continued)

FOREIGN PATENT DOCUMENTS

DE	19745734	4/1999	....	B60C 11/24
DE	19838638	3/2000	....	G01L 5/18

(Continued)

OTHER PUBLICATIONS

European Search report received by Applicant Nov. 23, 2015.

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(57) **ABSTRACT**

A tire-based system and method for estimating a radially outward tire surface temperature of an identified tire supporting an identified vehicle includes a temperature sensor to measure a tire inner liner temperature. An algorithmic prediction model is empirically trained to correlate inner liner tire temperature to tire radially outward surface temperature for the tire/vehicle combination. The empirically trained algorithmic prediction model receives a steady state temperature-based model inputs including the tire inner liner temperature and an ambient temperature measurement and transient behavior vehicle-based inputs. Based upon the steady state inputs and the transient behavior inputs, a radially outward tire surface temperature estimation is made.

10 Claims, 8 Drawing Sheets

Carcass deformation and hysteresis

Internal heat transfer (carcass and tread)

Air convection

Frictional energy due to sliding (lateral, longitudinal)

Conductive heat transfer (road surface to tread)